August 1960

ARS-33-60

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service

HONEY BEES IN PRODUCTION OF WHITE CLOVER SEED IN THE SOUTHERN STATES

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Pollinating insects are necessary for the production of white clover seed. Certain wild bees, principally bumble bees and solitary bees, pollinate white clover (Trifolium repens L.), but their number is small. Honey bees (Apis mellifera L.) are by far the most numerous pollinating agents, and their number in an area can be increased by moving colonies to the field.

Large fields of clover present a big job of pollination. An acre of white clover may contain from 1 to 3 million open florets per day during the flowering season, which, in the Southern States, is mainly in March, April, and May. Fortunately, white clover is attractive to honey bees as a source of both pollen and nectar.

Some honey bees gather only pollen from white clover, some only nectar, and many gather both. The nectar gatherers perform an important pollinating service, since they crawl over the pollen-bearing stigmas in order to reach the nectar at the base of the floret. Pollen grains cling to the finely branched hairs that cover the bee's body and are carried from one floret to another, thus effecting cross-pollination.

White clover is also an important pasture plant in parts of most Southern States, and its importance is likely to increase if the present program of pasture improvement expands. Here the seed producers have more flexibility in handling their clover fields than in the Northern States. Because of the mild weather, grazing may continue until late in the winter months. Fields that are to be reserved for seed production must have the animals removed about 8 weeks before the usual harvesttime. Clipping the fields immediately after animals are removed controls weeds and favors uniform blossoming. If the seed set and the weather at harvesttime justify it, the field can be harvested for seed. If not, the field can be cut for silage or returned to pasture. In the event that the grower does not own harvesting machinery, he may get a custom operator to mow and combine the crop on a share basis.

1/ In cooperation with Louisiana State University.

This report is concerned only with pollination in the production of white clover seed. Plants should be dense enough so that at harvesttime the field averages at least 500 seed heads per square yard. Harvesting machinery that is suitable for the crop must be used correctly; otherwise much seed will remain in the field. Although most of the information was obtained in Louisiana, it is believed that the recommendations given are generally applicable to all Southern States where white clover seed is produced.

Role of Honey Bees in Setting Clover Seed

Counts were made of the number of bees per square yard visiting the clover blossoms during 5-minute periods. These counts were made in different fields, at different times during the season, and over several years. Most of the bee activity took place between 9 a.m. and 5 p.m. Within one 5-minute period 11 bees per square yard were noted. The usual number under favorable conditions was 2 or 3. A bee sometimes visited up to 18 florets of a single head, but usually from 4 to 8. The seed set of white clover, calculated from samples in the fields, at different locations in Louisiana is given in table 1. In 1958 near Watson additional clover was growing in nearby pastures. In 1959 in two fields at Avoyelles Parish the number of colonies and the acres pollinated were not counted, but the grower estimated that there were 3 or more acres of clover to 1 colony of bees.

Table 1.--Seed set of white clover, calculated from field samples, at different locations in Louisiana, 1956-59.

Year	Location	Number of colonies	Acres pollinated	Seed set (lb./acre)
1956	Crowley	20	20	400
	Near Elton	50	280	530
1957	Montegut	40	400	187
1958	Near Watson	30	30	300
1959	Avoyelles Parish			
	Field 1	-	-	210
	Field 2	-	-	336

Factors Influencing Bee Activity on White Clover

The activity of bees on white clover blossoms is affected by the weather, colony strength, and competition from other plants within flight range of the colony.

In Louisiana honey bees work best on white clover under the following conditions: temperature between 80° and 90° F., light to no wind, clear to partly cloudy sky, and relative humidity below 60 percent. Usually there is enough favorable weather during clover bloom so that bees can adequately pollinate it. Bumble bees are active under a wider range of weather conditions than honey bees; they visit blossoms even on cool, misty days.

Strong colonies--that is, those with a population of about 50,000 bees by April 1--are best for pollination. Such colonies will require hives that are about four stories high. A strong colony sends a higher percentage of its total force to the field than a weak one. So that the colony can keep a large population, swarming must be prevented by proper management. An experienced beekeeper is needed to maintain colonies at effective pollination strength when clover is in bloom.

Nectar-collecting honey bees may reduce their visits to white clover if other plants are in bloom. The following plants provide easily accessible nectar and bloom concurrently with white clover:

Crimson clover (Trifolium incarnatum L.)
Blackberry (Rubus sp.)
American holly (Ilex opaca Ait.)
Honeylocust (Gleditsia sp.)
Wild grape (Vitis sp.)
Persian clover (Trifolium resupinatum L.)
Rattan vine (Berchemia scandens (Hill) K. Koch)
White sweetclover (Melilotus alba Desr.)
Vervain (Verbena sp.)

There is no practicable way for the seed producer to keep pollinating bees working his clover blossoms if other attractive species are in bloom. However, there are periods during the spring when competition is of no consequence, and a satisfactory seed set may be obtained.

Other white clover growing in the area probably provides the greatest competition for bees placed for pollination of a seed field. The solution of this problem is to increase the number of colonies so there are enough bees to visit all the blossoms within flight range of the apiary.

When white clover was first grown for seed at the Rice Experiment Station at Crowley, there were no other known clover fields nearby. Consequently most of the bees provided for pollination probably worked the blossoms of the seed field. Within 5 years considerable clover was present in both the station pastures and nearby fields. This illustrates how conditions may change within a few years. There was no known source of pollen or nectar within a mile or more of the field near Elton. It is believed that the bees confined their activity to the clover field.

Competition from clover growing near seed fields has been a factor in the lower Mississippi valley for many years. In the rice-growing area, where white clover seed production is a recent enterprise, there has been practically no competition from nearby fields. However, the recommended rotation of white clover in pastures followed by rice is rapidly increasing the clover acreage. This practice provides heavy competition for the work of the bees introduced for the pollination of particular fields. Clover in adjacent fields is in bloom during the entire spring season unless it is mowed. Even then, blossoms may soon appear.

Nectar Production by White Clover

Nectar production by clover florets is an important factor in attracting insect pollinators. Louisiana common white clover in pastures yielded 4.8 microliters of nectar per blossom in 1952 and 3.2 microliters in 1955 (Oertel 4). Louisiana S-1 strain from field plots produced 8.6 microliters per blossom compared to 8.1, 7.3, and 4.6 microliters from other strains. These results indicate that better nectar-yielding strains of white clover can be selected, which should improve the attractiveness of seed fields to honey bees.

Bailey et al. (1) found that in 1952 there was a general increase in nectar production per blossom as the season progressed, maximum production being reached on June 6. Little is known about the factors that affect nectar production. When several blossoms of about the same age were taken from a plant, it was not unusual to find that at least one contained no nectar.

Seed Production by White Clover

Two methods of obtaining seed-set values from fields were used--100 dry heads with dry stems, taken at random; and the total heads per square yard. Samples were taken at different times during the growing season over several years.

The samples from fields containing colonies of bees gave an average of 0.25 ounce of seed per 100 heads. Samples from fields where there were no known bee colonies yielded 0.18 ounce. In these fields honey bees were seen on blossoms, but there were no colonies known to be near. It was impossible to establish the number of bee trees within flight distance. A yield of 0.25 ounce per 100 heads indicates a potential yield of 387 pounds per acre, whereas 0.18 ounce per 100 heads indicates 267 pounds per acre.

Samples containing the clover in square-yard areas were taken from fields where colonies of bees provided pollination. Such samples contained an average of 500 heads, consisting of blossoms, green and dry heads, and partly shattered old heads. An average of 0.70 ounce of seed was threshed from these samples.

The apparent discrepancy between the weight of seeds obtained by the two methods is probably accounted for by the blossoms which contained no seeds, the green heads which contained partly developed seed, and shattered heads which were only partly harvested.

Methods of Estimating Effective Pollination

Pollen is needed by bees to provide protein for the developing larvae. Large amounts are used in the spring when brood rearing is at its height. In previous studies (Oertel 3) from 1 to 3 ounces of clover pollen was collected per day in a trap at the entrance of a hive. An unknown additional amount was carried through the trap. A clover floret produced about 3,000 pollen grains, and a clover pollen pellet contained about 388,000 pollen grains. Calculations based on these figures indicate that one pollen-collecting trip by one honey bee might result in the formation of 260 to 3,640 seeds.

The possible seed set per acre has been estimated in a different manner in table 2. It may be considered that the calculated seed set cannot be reached. With improvements in both field and pollination management the evidence indicates that such a set could be approached. The largest seed set per square-yard sample was taken at Crowley in 1956. It contained 744 dry heads that produced 2.17 ounces of seed, a rate of 656 pounds per acre. There are 900,000 to 1,000,000 Louisiana white clover seeds in a pound. The best samples of 100 dry heads gave a yield of 0.51 ounce, which was 75 percent more per head than was obtained from the best square-yard samples. Erith (2) reported that a single white clover floret is capable of producing seven seeds. Probably such production is seldom reached in the field. A commercial seed grower should not be satisfied with a seed set of less than 2 per floret (100-140 per head) and should try for at least 4 per floret. Blossoms early in the season had an average of 70 florets whereas those that bloomed late had 50.

Table 2.--Calculated set of clover seed per acre.

Number of blossoms per square yard	Pounds of seed per acre[1/]	
	50 florets per blossom	70 florets per blossom
300	320	448
500	533	747
700	747	1,045
900	960	1,344

1/ Based upon a set of 2 seeds per floret. With 4 seeds per floret the yield is doubled.

Relation Between Seed Set and Seed Harvest

Under ideal conditions a close relationship would be expected between the set in a field and the amount harvested. The grower is mainly concerned with the amount harvested, but a beekeeper who furnishes bees for pollination is mostly concerned with the amount of seed set. The beekeeper believes that if seed is present the bees have done their job, and it is up to the grower to harvest the crop. A grower knows that unfavorable weather may greatly reduce the amount of seed harvested or even prevent harvest entirely. For example, in 1957 tropical storm "Audrey" covered some fields with nearly a foot of water. A part of the seed was harvested from fields that drained rapidly, but in other fields the crop appeared to be beyond recovery. Another example occurred in 1959 in the vicinity of Baton Rouge. From May 20 to June 20, the usual seed-harvest period, rain fell on 22 days; thus harvesting was prevented.

The effect of unfavorable weather upon the amount of seed harvested is indicated in table 3 by the lower yields of the Southern States (5). Their yields were roughly 10 to 20 percent of the calculated yields, based on samples of actual seed set. Failure to use harvesting machinery properly accounts for heavy seed losses. In one test rethreshing of material that had gone through the combine showed a recovery of 50 pounds of seed per acre. In other tests from 1 to 6 percent by weight of the material that passed through the combine consisted of clover seed. Equipment used by a successful Louisiana seed grower recovered all but 11 pounds of seed per ton of dry material in a field that showed a calculated set of 210 pounds per acre.

The combine should be carefully adjusted to save all the seed even though considerable foreign material must be cleaned out later. The ground speed should be slow, probably not over 2 miles per hour, unless the swath is rather light. It is particularly important that the swath be well dried. Under some conditions Louisiana growers could employ a chemical defoliant to eliminate excess vegetation or they might find that early cutting of a portion of the seed crop, followed by a second cutting, would be profitable over a period of years. Accurate, long-range weather forecasts would be of great value to seed growers. A light seed-tight rack could be built to collect straw blown through the combine, which could then be rethreshed in a stationary combine or thresher.

Table 3.--Production of white clover seed in six States, 1946-1957.

State	Acres harvested		Yield (pounds per acre)	
	1946-55	1957	1946-55	1957
Idaho	8,140	18,000	228	250
Wisconsin	2,210	600	170	110
Oregon	1,280	2,500	127	150
Mississippi	4,720	1,500	72	50
Alabama	5,929	2,000	68	60
Louisiana	11,400	11,500	52	55

Insect Enemies of Clover

White clover has some insect enemies which cause severe damage at times and minor damage more frequently. Dan F. Clower (personal communication)2/ states that the variegated cutworm (Peridroma saucia (Hübner)), the armyworm Pseudaletia unipuncta (Haw.), the corn earworm (Heliothis zea (Boddie)), and the legume mite Petrobia apicalis (Banks) sometimes cause enough damage to require an insecticide. Most seed producers do not have equipment to apply insecticides to the clover plants. The value of the potential seed loss may not justify the use of insecticides since the fields can be used for pasture most of the year.

Improvement of Pollination by Honey Bees and Other Insects

No special bee management practices have been developed to increase clover pollination. It is recommended, however, that only large colonies with young queens be used, since such colonies send large numbers of pollen and nectar gatherers to the field. Fortunately clover blooms in the spring when bee colonies normally are increasing rapidly in population.

It is recommended that colonies of bees for pollination be located by April 1. They may be placed near the edge of fields of 50 acres or less and near the center of larger fields. The seed grower should remember that bees sometimes fly a mile or more in all directions from the hive. One colony per acre is believed sufficient to provide pollination for seed fields where nearby fields contain white clover. One colony to 3 acres is probably adequate where there is little or no competition from other species or nearby clover fields. The seed grower must remember that bees cannot be compelled to work on the blossoms of a particular field. They are known to exercise preferences. Experiments are needed to determine whether increasing the number of colonies per acre of clover will generally result in a profitable increase in seed set.

Pollination Service to Seed Growers

In Louisiana, Mississippi, and Alabama honey bee colonies are not moved frequently. The beekeepers prefer permanent locations if the honey crop is satisfactory. Seed growers can often obtain plenty of bees for pollination by offering free apiary sites in or adjacent to their seed fields. A few pay a rental fee for the use of colonies during clover bloom; others own some colonies. The beekeeper is entitled to a reasonable rental fee or a satisfactory honey crop. A fee of $4-8 per colony is believed to be fair to the grower and the beekeeper. A brief, written rental agreement will avoid misunderstandings.

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